

## Original Article

# Biodiversity of macro-benthic and physicochemical quality (IRWQIsc) and toxic (IRWQIst) indices in the rivers of the Maharloo wetland basin

Hamid Zohrabi<sup>1</sup>, Atefeh Chamani<sup>\*2</sup>, Mehrdad Zamanpoore<sup>3</sup>, Kamran Rezaei Tavabe<sup>4</sup>

<sup>1</sup>Environmental Science and Engineering Department, Isfahan (Khorasgan) Branch, Islamic Azad University, Esfahān, Iran.

<sup>2</sup>Environmental Science and Engineering Department, Waste and Wastewater Research Center, Isfahan (Khorasgan) Branch, Islamic Azad University, Esfahān, Iran.

<sup>3</sup>Department of Hydrobiology, Agricultural Research Education and Extension Organization of Iran, Fars Agricultural and Natural Resources Research and Education Center, Shiraz, Iran.

<sup>4</sup>Department of Fisheries, Natural Resources Faculty, University of Tehran, Karaj, Iran.

**Abstract:** The Maharloo Wetland in the Fars Province has a great ecosystem and socio-economic importance for the city of Shiraz. The two rivers, Chenarrahdar and Khoshk River, as well as some springs in this basin, are the main suppliers of water to the wetland. These two rivers originate upstream of Shiraz city and, after passing through Shiraz city and receiving various wastewaters and pollutants, reach the Maharloo Wetland in the southeast of Shiraz city. This study was conducted to investigate the biodiversity of benthic organisms and the physicochemical and toxicity status of the rivers in the Maharloo watershed. Water and benthic organisms were sampled from 12 stations from the two rivers and springs, and the biological indices of benthic organisms, water quality, and water toxicity were evaluated in four seasons. According to the results, in all four sampling seasons, the water quality index (IRWQIsc) and toxicity index (IRWQIst) were suitable at the upstream stations and before the rivers enter the city of Shiraz, due to the entry of various types of domestic, agricultural, industrial and surface sewage of the city, these two indices are severely reduced and reach a severely polluted and critical ecosystem eutrophication condition. For studies of the benthic fauna of the rivers of the Maharloo watershed, sampling was performed at the stations. Then the benthic biodiversity indices, including HFBI, BMWP, ASPT, and Shannon-Wiener, were examined and evaluated. Based on the results of the biological indices, the biological communities in the rivers are completely different before entering the city of Shiraz and after that, and in parts of both rivers in the downstream stations, anaerobic conditions are created, and the possibility of life for benthic fauna is lost. The dominant benthic communities at the sampling stations before entering Shiraz city were mainly from the families Caenidae, Tipulidae, Baetidae, Gammaridae, Hydropsychidae, and Dytiscidae, but at the downstream stations within Shiraz city and the entrance to Maharloo Wetland, the dominant benthic communities were mainly from the families Naididae, Culicidae, Staphylinidae, Erpobdellidae, and Tubificidae. According to the results, the need to develop a comprehensive quality management program for basin entering the two rivers of Shiraz, Chenarrahdar and Khoshk, is essential to improve the ecosystem of the rivers in the basin and the Maharloo Wetland.

### Article history:

Received 11 January 2025

Accepted 10 April 2025

Available online 25 April 2025

### Keywords:

Biodiversity

Wetland

River

Ecotoxicity

## Introduction

Rivers are crucial sources of renewable water supply for humans and freshwater ecosystems, providing numerous goods and services such as domestic uses, navigation, recreational activities, and habitats for many organisms (Rezaei Tavabe et al., 2017). These water bodies are most vulnerable to pollution due to easy accessibility for the disposal of wastewater. Discharging organic and inorganic pollutants, as well as nutrients, is a major cause of river water quality

deterioration (Mehrdadi et al., 2006). Both natural processes, such as precipitation inputs, erosion, and weathering of crustal materials, as well as anthropogenic influences, including urban, industrial, and agricultural activities, and the increasing exploitation of water resources, together determine the quality of surface water in a region (Singh et al., 2004). Rivers are the most important aquatic ecosystems in the semi-arid regions of Iran's central basin, which originate in the margins of the highlands

\*Correspondence: Atefeh Chamani  
E-mail: atefehchamani@yahoo.com

and then terminate in the central plateau. These rivers are worthwhile in terms of biodiversity, social, economic, and drinking water in arid and semi-arid regions. Local variations in water quality can be assessed by chemical parameters or biological effects. Thus, the relationship between aquatic benthos and water quality can be studied at several spatial levels (Rezaei Tavabe et al., 2010). All environments vary, and organisms exploiting them are likely to evolve adaptations for dealing with fluctuations in favorability (Vali et al., 2020).

Eutrophication is a limnological concept for a process in which minerals or nutrients enrich a water body (Harper, 1992; Ansari et al., 2010). Prior to human interference, this process was a slow phenomenon in which nutrients, especially phosphorus compounds, accumulated in water bodies. Eutrophication, caused by human activities, is a rapid process in which nutrients enter water resources through pollutants, including sewage, industrial wastewater, and agricultural runoff. This process reduces the oxygen in water due to the decomposition of organic matter during the mineralization process (Raymont, 2014). Eutrophication is the process of increasing the production of biomass in a water body, characterized by the accumulation of plant nutrients, particularly phosphorus, nitrate, or other nitrogen compounds. By continuing the process, the water body biomass increases, but biodiversity decreases. In severe eutrophication, with excessive bacterial biomass degradation, it can lead to anaerobic conditions.

The Maharloo wetland basin, located in the southwest of the country, covers an area of 459,200 hectares, encompassing the city of Shiraz and a significant portion of the population of Fars Province. The high population density and abundance of polluting sources, such as industrial wastewaters, service centers, agricultural drainage, waste disposal, and landfill centers, cause significant changes in the quality of water resources from the upstream to the downstream areas of the rivers and the Maharloo Wetland. These negative consequences, in addition to the severe environmental changes they have caused,

can also pose serious risks to the health of the watershed residents and the region's environment. The two rivers, Chenarrahdar and Khoshk, are the main water sources supplying the Maharloo Wetland. These two rivers flow from the middle and southeastern parts of Shiraz to the Maharloo Wetland. The entry of various types of wastewaters into these two rivers severely affects their biological and ecosystem conditions, as well as the Maharloo Basin. In the downstream parts of these two rivers, the biochemical cycle conditions of the main biogenic substances, including nitrogen, phosphorus, sulfur, and carbon, become anaerobic, creating an unpleasant odor in the south of Shiraz. Accurately understanding the biodiversity of this important basin, examining the degree of impact of this ecosystem on human activities, and finding ways to protect and restore it are among the necessities of this research.

Investigating the type, amount, and distribution of toxic and dangerous pollutants such as heavy metals and their changes in the course of rivers leading to the wetland that pass through concentrated population centers is not only necessary, but also vital, because contaminated sediments from mainly seasonal rivers and the Maharloo wetland during the dry seasons can reach important population centers in the region, such as the cities of Shiraz, Kavar, Sarvestan, and surrounding villages, by rising and emitting dust, posing serious threats to the health of citizens. Therefore, the present study was conducted to assess the biodiversity of macrobenthic organisms and the physicochemical quality (IRWQIsc) and toxic (IRWQIst) indices in the rivers draining into the Maharloo wetland basin, South of Iran.

## Materials and Methods

**Sampling stations:** In 2024, water and macrobenthic organism sampling were conducted at 12 sampling stations in the Maharloo watershed basin (Table 1, Fig. 1) across four seasons. The sampling network was designed to cover a wide range of determinants at key sites, which reasonably represent the water quality of the river system according to branches and pollutant points that impact water quality and macro-benthic

Table 1. Location and geographic point of sampling stations.

Station number	Station	Geographic point
1	Qalat-Shab-Shotori	29°49'0.31"N, 52°17'58.46"E
2	Tang-Sorkh	29°41'15.42"N, 52°28'40.99"E
3	Pas-kohak	29°44'2.11"N, 52°16'48.33"E
4	Pol-Gachi	29°34'33.99"N, 52°28'56.67"E
5	Soltanabad	29°32'27.21"N, 52°33'17.05"E
6	Pol-Fasa	29°29'3.36"N, 52°38'14.29"E
7	Entrance of Maharloo Wetland	29°29'10.40"N, 52°40'32.88"E
8	Khaljooi	29°33'32.12"N, 52°41'20.14"E
9	End of Khoshk River	29°31'8.96"N, 52°42'25.56"E
10	Roknabad Spring	29°42'26.95"N, 52°34'5.49"E
11	Upstream of Chenarrahdar river	29°37'50.00"N, 52°21'42.00"E
12	Ab-Garam Maharloo Spring	29°21'0.00"N, 52°49'0.00"E

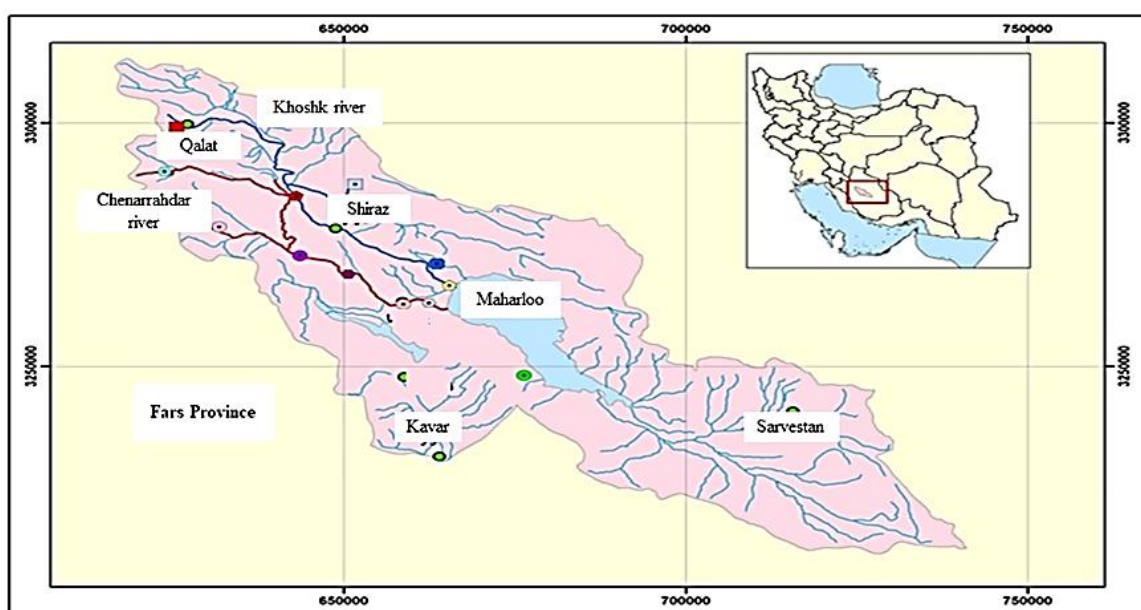


Figure 1. Maharloo watershed basin and geographical distribution of sampling points.

organisms.

**Water sampling and analysis:** Water samples were collected each season at three points (1/4, 1/2, and 3/4) across the sampling points. For each point, 250 mL of samples were collected (Fig. 2) in sampling bottles and transferred to the Water and Wastewater Laboratory of the Faculty of Natural Resources, University of Tehran, for physicochemical analyses and toxicity index determination. To assess the quality status and pollution of water at the sampling stations, the Iranian Surface Water Quality Standard Index (IRWQI<sub>sc</sub>) was used, which is a combined index of NSFQI and BCEQI (Mehrdadi et al., 2006), which is optimized for the country's surface water resources

by weighting 11 main water quality factors including BOD, COD, pH, nitrate, phosphate, DO, TDS, EC, ammonium, turbidity, total hardness, and fecal coliforms, and provides a quantitative representation of the water quality status in ecosystems and water resources. The quantitative number obtained is in the numerical range of 0 to 100. Also, to determine the toxicity index, ICP and gas chromatography (GC) devices were used.

Heavy metals were read using a TERMO ICP-OES device, model ICP6000. Toxic indices of total petroleum hydrocarbons (TPH), phenol, total detergents, and cyanide were also measured and read using a GC model 7890A gas chromatography device



Figure 2. Water sampling for analysis of IRWQIsc and IRWQIst indices.



Figure 3. Sampling and identification of macro-benthic organisms.

from Agilent, USA. The amount and type of polycyclic aromatic hydrocarbons (PAH) were also determined on the collected samples (EPA, 2006). After preparing the extract, according to the instructions, PAHs were extracted, separated, identified, and quantified. IRWQI<sub>ST</sub> was used to evaluate and determine the toxicity index.

**Macro-benthic sampling and analysis:** For sampling of the macro-benthic organisms, a Surber sampler was used, which after collection and separation with meshes less than 0.1 mm, were fixed in 4% formalin and transferred to the Aquatic Biology Laboratory of the Faculty of Natural Resources, University of Tehran for identification (Fig. 3). The identification and biodiversity of the samples from each sampling station were determined under a Tissa company binocular loupe, model Cs-5CAW (China), using valid and standard identification keys and then the benthic biodiversity indices including ASPT,

HFBI, BMWP, and Shannon-Wiener were examined and evaluated (McIntyre and Eleftheriou, 2005).

The Average Score per Taxon (ASPT) is a water quality index that rates benthic invertebrate families according to their sensitivity to dissolved oxygen depletion. The ASPT index was primarily developed to detect water pollution caused by organic matter, and for this reason, it is also sensitive to the effects of eutrophication in water resources (Ansari et al., 2010). The Biological Monitoring Working Party (BMWP) is a method for assessing water quality using families of macroinvertebrates as biological indicators. The method is based on the principle that different aquatic invertebrates have different tolerances to pollutants. In the case of BMWP, this is based on the sensitivity/tolerance to organic pollution, and it is important to recognize that the ranking of sensitivity/tolerance will vary for different types of pollution.

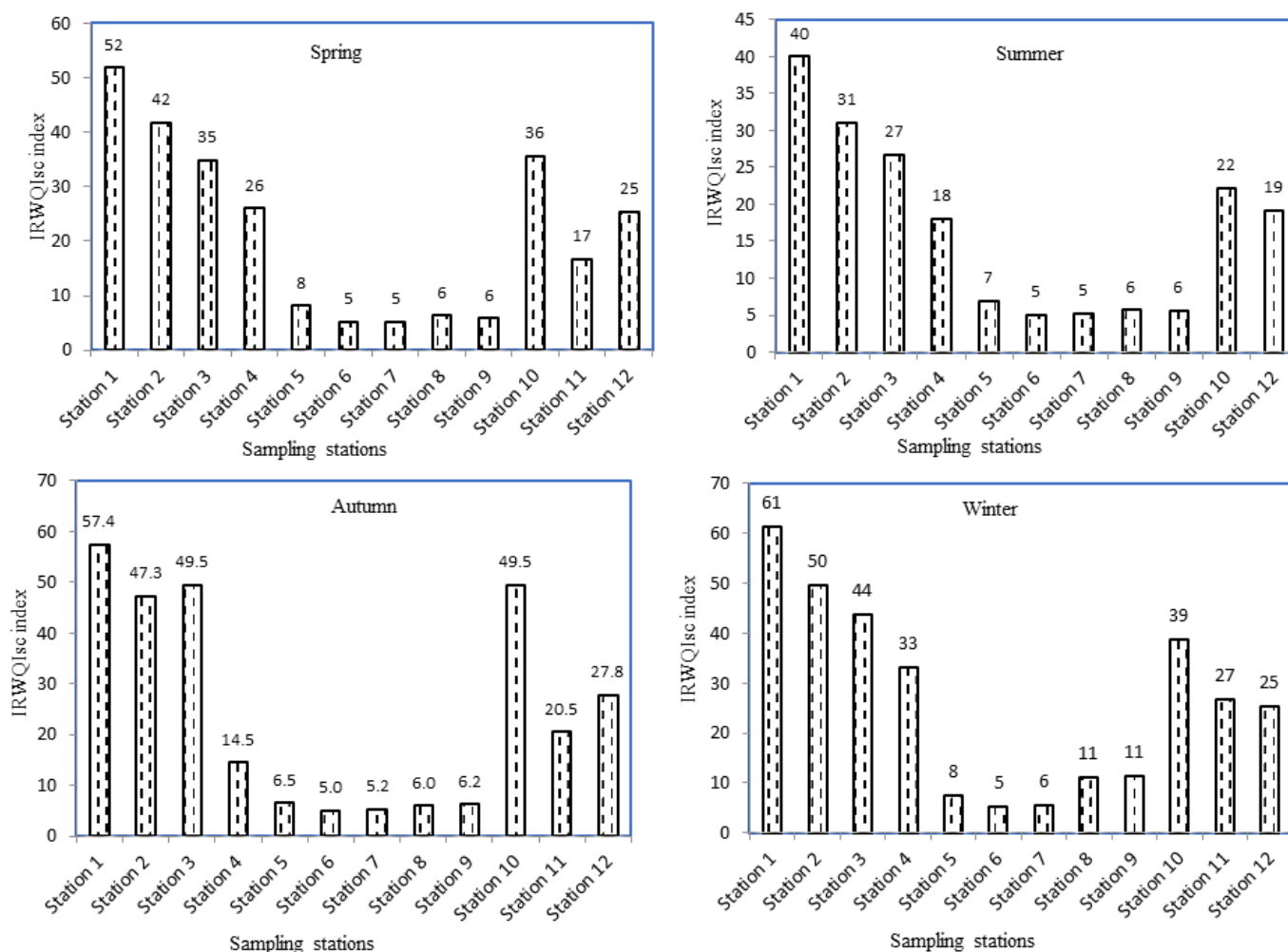


Figure 4. IRWQIsc index at sampling stations at different seasons.

**Statistical analysis:** The data were normalized by the Shapiro-Wilk test and then analyzed statistically. They were subjected to a one-way ANOVA, and significant differences between the means were compared using Duncan's test. Statistical significance was assessed at a 0.05 probability level using SPSS version 23.0.

## Results

Based on the IRWQIsc results at the studied stations, in all four seasons, from Station 4 in the Shiraz area, Pol-Gachi station, to Station 9 at the end of the Khoshk River, the conditions are extremely unfavorable. It has a very poor-quality class due to the entry of various wastewaters. In the upstream stations of Shiraz city and also in the sampled springs, the IRWQIsc index is relatively suitable and acceptable (Fig. 4). The IRWQIst index is also an incorporated index for

assessing the status of toxins and heavy metals in surface waters, which is obtained by weighting 11 toxic parameters using a ranking curve. Due to the entry of various types of industrial, sanitary, factory, hospital, agricultural, and urban-domestic wastewaters into the two studied rivers of Chenarrahdar and Khoshk at the studied stations in the southern part of Shiraz city, to the entrance to Maharloo wetland, this index was in very inappropriate and toxic numerical conditions. So that in spring and summer at station number 9 in the area of the entrance to Maharloo wetland, this number is 2.2 and 2.8, respectively, which indicates the very destructive conditions of the status of toxins in this area (Fig. 5).

At some studied stations, no benthic species were observed or sampled during the summer, autumn, and winter seasons. Based on physicochemical analyses,

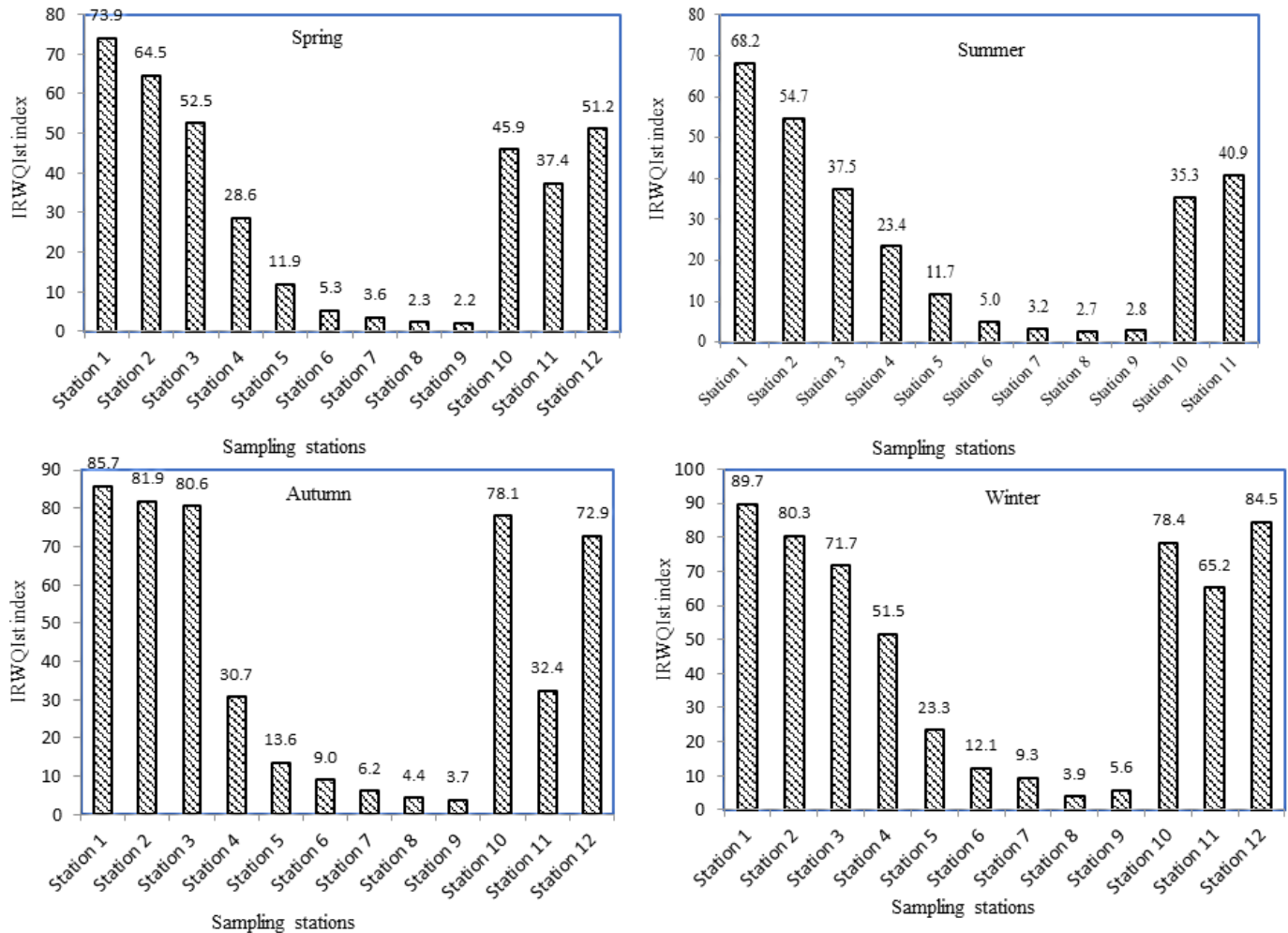


Figure 5. IRWQIst index at sampling stations at different seasons.

anaerobic conditions were observed in these areas at the time of sampling, with a dissolved oxygen (DO) level of approximately zero and an oxidation-reduction potential (ORP) index that was also negative. In the spring and summer seasons, when benthic diversity and reproduction were higher, the ASPT index number in the stations in the Shiraz city area was 2, which is in the severe pollution class (Fig. 6). Based on the BMWP results at the stations upstream of Shiraz city, in both studied rivers, the biodiversity of benthic organisms was high. The benthic organisms were mainly groups sensitive to pollution and oxygen depletion. At the stations leading to the Maharloo wetland, not only was the biodiversity of benthic organisms severely reduced, but only benthic organisms able to tolerate harsh environmental conditions and severe pollution were

present (Fig. 7).

The results of the two indices, Shannon-Wiener and HBI, are presented in Figures 8 and 9. To some extent, the results of both indices are similar and consistent. In stations that are not exposed to pollution or wastewaters, benthic groups sensitive to environmental conditions are present. In polluted and heavily polluted stations, either no benthic organisms are present or only benthic families that are very resistant to environmental conditions are identified. So, the dominant benthic communities at the sampling stations before entering Shiraz city were mainly from the families Caenidae, Tipulidae, Baetidae, Gammaridae, Hydropsychidae, and Dytiscidae, but at the downstream stations within Shiraz city and the entrance to Maharloo Wetland, the dominant benthic communities were mainly from the families Naididae,

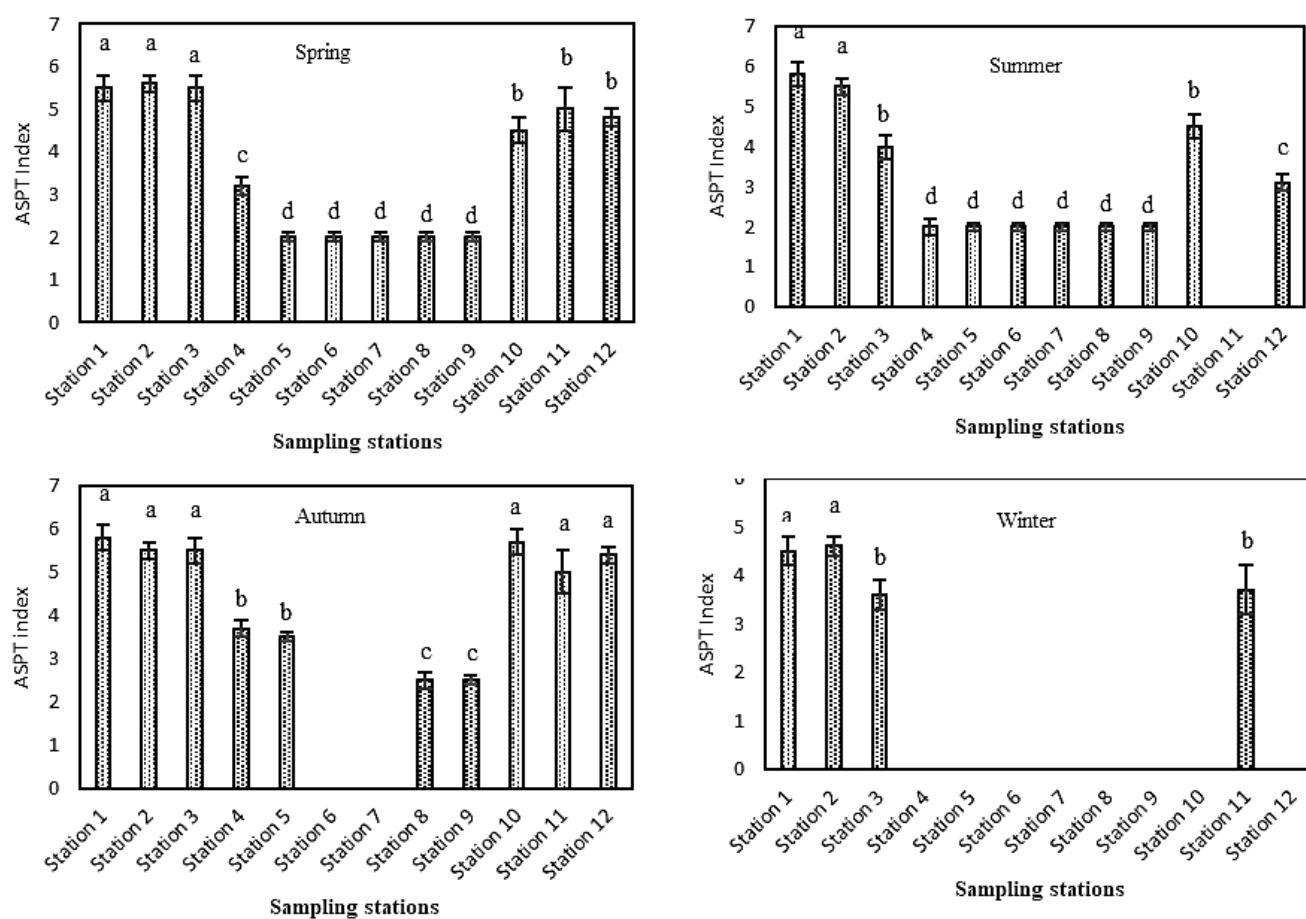


Figure 6. ASPT index at sampling stations at different seasons.

Culicidae, Staphylinidae, Erpobdellidae, and Tubificidae.

## Discussions

Rivers are essential ecosystems with high ecological value, and the health of these ecosystems is important for the human societies that depend on them (Rezaei Tavabe et al., 2018). Knowledge about water quality parameters is an integral part of environmental monitoring and determining the condition of habitats. When water quality is poor, it affects not only aquatic life but also the health of the aquatic ecosystem. This section details some parameters that affect water quality and aquatic ecosystem health. These environments receive large amounts of wastewater due to increasing production and applications, which are often discharged directly or through hydrological processes, annually (Ashori et al., 2019), causing adverse effects on aquatic organisms (Nezhadheydari et al., 2019). Shiraz city, with a population of about 2

million people, and its surrounding industrial estates and agricultural activities have the potential to produce a large amount of wastewater that flows into the two Chenarrahdar and Khoshk rivers, as well as the Maharloo Wetland. The present study showed that in all four seasons from station 4 in the Shiraz area, Pol-Gachi station, to station number 9 at the end of the Khoshk River, the conditions are extremely unfavorable and have a very bad quality class due to the entry of various wastewaters. While in the upstream stations of Shiraz city and the sampled springs, the IRWQIsc and IRWQIst indices are relatively suitable and acceptable. Macroinvertebrate metrics are helpful tools for assessing water quality and overall aquatic ecosystem health. The changes in benthic communities and their biodiversity at these stations confirm the drastic changes in the biological conditions of both the rivers and the Maharloo Wetland.

More important than the water quality index in the

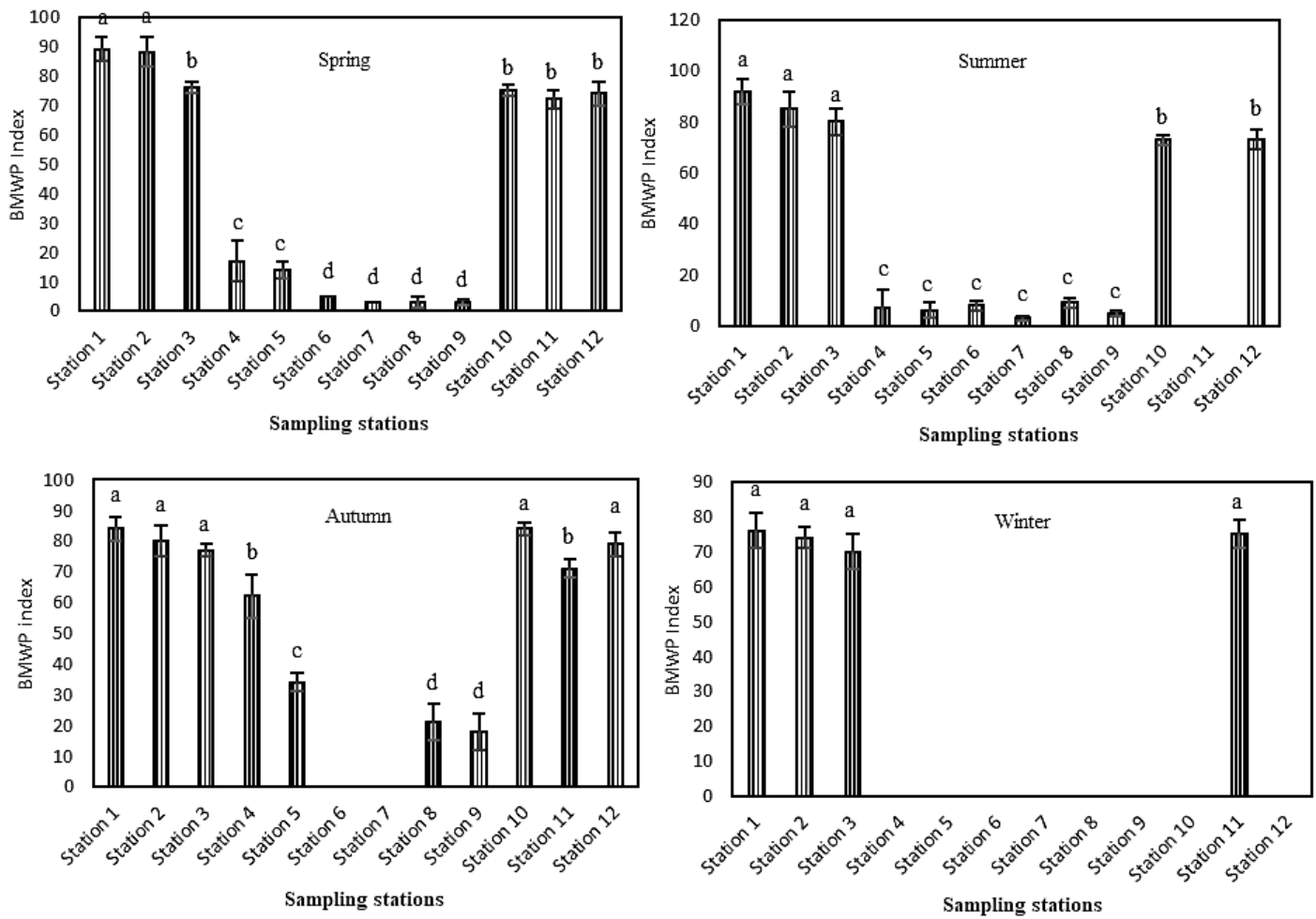


Figure 7. BMWP index at sampling stations at different seasons.

rivers of the Maharloo Wetland watershed basin area is the IRWQIst index, which in the downstream areas of both rivers is very worrying for the ecosystem conditions of the Maharloo Wetland and the two rivers themselves. According to the results from spring and summer at the Shiraz area near the entrance to the Maharloo wetland, this number is approximately 2, indicating the very destructive conditions of the toxins in this area, which eventually enter the Maharloo wetland ecosystem. Freshwater riverine systems are facing a series of stresses due to different anthropogenic activities, eutrophication, and geomorphological alterations. Pollution is a current ecological hazard leading to deterioration in river water quality, thereby altering the quantitative distribution of inhabiting organisms.

In the two rivers studied in the Maharloo Wetland Basin, the toxins were mainly heavy metals and

organic toxins, which have significant biologically destructive effects on benthic organisms. In addition to causing environmental stress, various toxins directly affect the physiological conditions and reproduction of benthic organisms, as animal cells and tissues can easily absorb them due to their small size (Rafiee et al., 2014; Javanmardi et al., 2018; Rezaei Tavabe et al., 2019, 2020). Structure, size, solubility, ability to cross different barriers, accumulation within the system, generation of oxidants, ability to percolate into the nucleus, exposure time, and bio-concentration are main features of toxins and heavy metals in human health, environment, and bio-organism’s physiology (Rezaei Tavabe et al., 2013, 2020). Although the Maharloo Wetland lacks biodiversity due to high water salinity, the high volume of toxins and heavy metals entering this wetland will have significant ecosystem effects in the region, necessitating

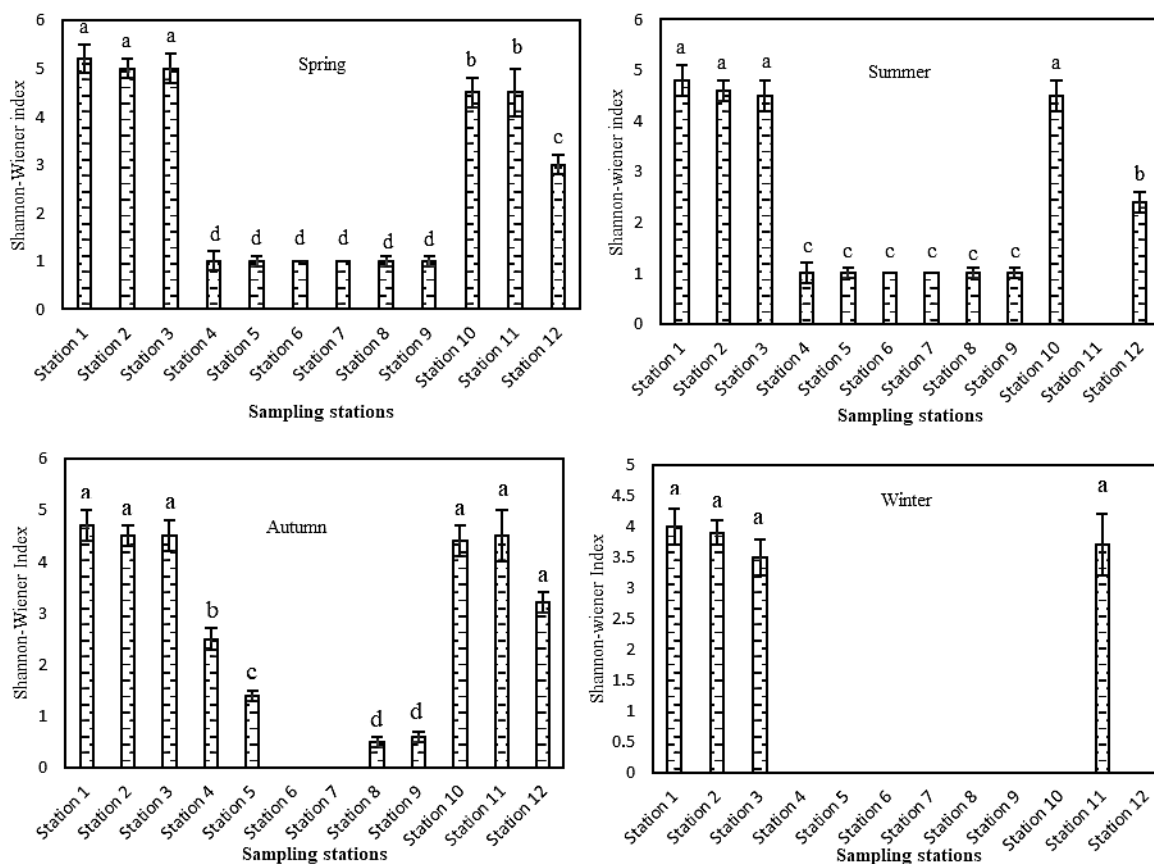


Figure 8. Shannon-Wiener index at sampling stations at different seasons.

wastewater management.

Biota in aquatic ecosystems are usually exposed to diverse stress conditions and anthropogenic disturbances (Bertrand et al., 2018). Bio-indicators and bio-monitors are organisms that contain information on the quality of the environment and ecosystem (Markert et al., 1999). An ideal bio-indicator should have at least the characteristics, including easy recognition, wide distribution, low mobility, well-known ecological characteristics, numerical abundance, and high sensitivity to environmental stressors (Hilty and Merenlender, 2000; Rezaei Tavabe et al., 2010). The freshwater macroinvertebrate taxa vary in response to organic pollution, and thus, their diversity and composition have been used to infer pollution loads (Javanmardi et al., 2020). According to the results, the dominant benthic communities at the sampling stations of the Maharloo Wetland basin before entering Shiraz city were mainly from the families Caenidae, Tipulidae, Baetidae, Gammaridae, Hydropsychidae, and

Dytiscidae, but at the downstream stations within Shiraz city and the entrance to the wetland, the dominant benthic communities were mainly from the families Naididae, Culicidae, Staphylinidae, Erpobdellidae, and Tubificidae. Some phylum-class taxa could effectively indicate the ecological integrity associated with water quality. This could be explained by the fact that these phylum-classes were dominated by taxa with the same or very few different lifestyles that could point out a single category of pollution (Rafiee et al., 2015). In the rivers of the Maharloo Wetland basin, IRWQIsc and IRWQIst indices indicate changes in biological communities and their various indicators. For this reason, it is necessary to develop a comprehensive program for quality monitoring and management of wastewaters entering the rivers of the Maharloo Wetland.

## Conclusion

Shiraz city, with a population of approximately 2 million people, and its surrounding industrial estates

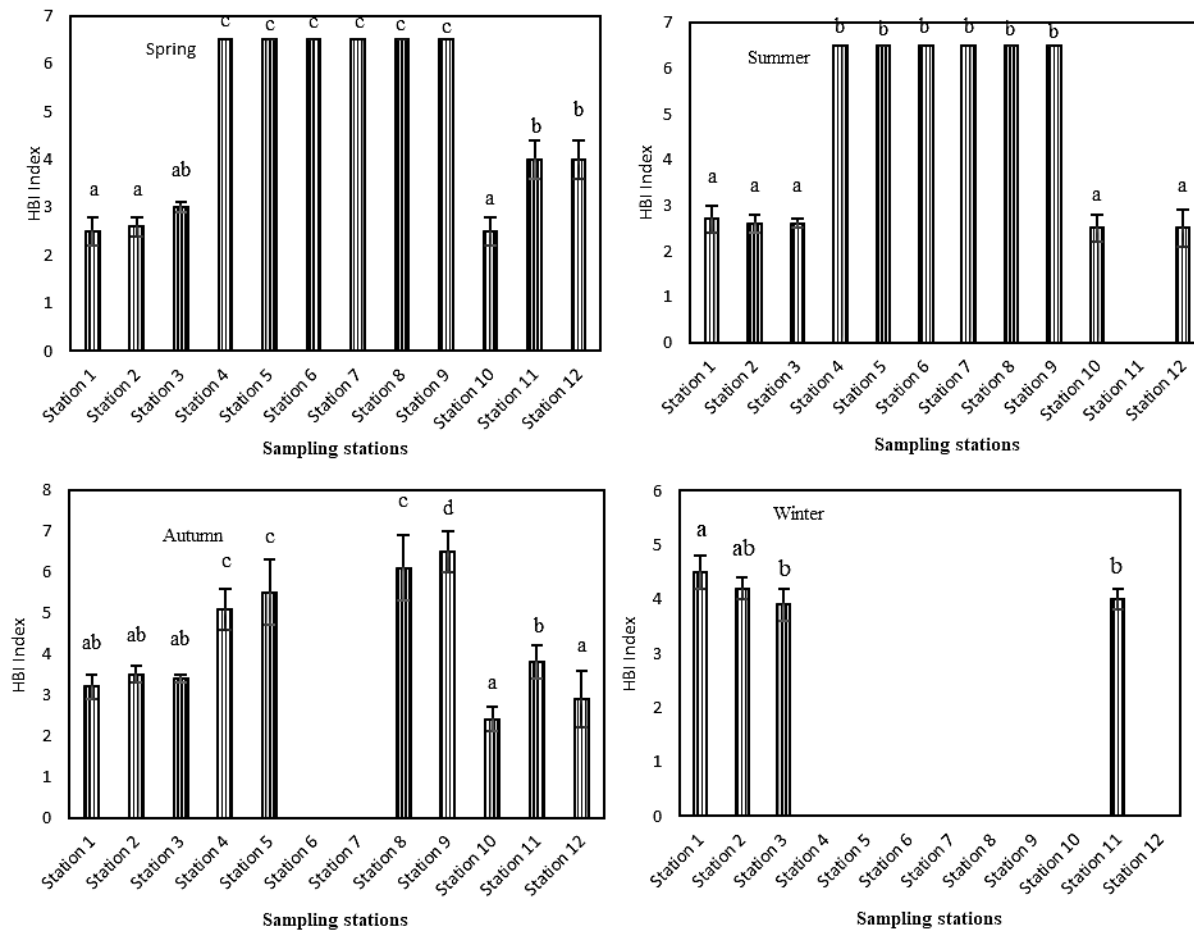


Figure 9. HBI index at sampling stations at different seasons.

and agricultural activities have the potential to generate a substantial amount of wastewater for the two Chenarrahdar and Khoshk rivers, as well as the Maharloo wetland. The present study showed that, from station number 4 in the Shiraz area, known as Pol-Gachi station, to station number 9 at the end of the Khoshk River, the conditions are extremely unfavorable and the quality class is very poor due to the entry of various wastewaters. While in the upstream stations of Shiraz city and also in the sampled springs, the IRWQIsc and IRWQIst indices are relatively suitable and acceptable. The biological communities in the rivers are completely different before entering the city of Shiraz and after that. In parts of both rivers, particularly at the downstream stations, anaerobic conditions are created, and the possibility of life for benthic fauna is lost. According to the results, developing a comprehensive quality management program for wastewater entering the two

rivers of Shiraz, Chenarrahdar and Khoshk, is extremely necessary to improve the ecosystem of the rivers in the basin and the Maharloo Wetland.

**Acknowledgment**

The authors would like to acknowledge the financial support of the Fars Province Department of Environmental Office for this research under grant project number 5975.

**References**

Ansari A.A., Singh G.S., Lanza G.R., Rast W. (2010). Eutrophication: causes, consequences and control (Vol. 1). Springer Science and Business Media.  
 Ashori A., Rafieyan F., Kian F., Jonoobi M., Rezaei Tavabe K. (2019). Effect of cellulose nanocrystals on performance of polyethersulfone nanocomposite membranes using electrospinning technique. *Polymer Composites*, 40: E835-E841.

- Bertrand L., Monferrán M.V., Mouneyrac C., Amé M.V. (2018). Native crustacean species as a bioindicator of freshwater ecosystem pollution: A multivariate and integrative study of multi-biomarker response in active river monitoring. *Chemosphere*, 206: 265-277.
- EPA (2006). Method for chemical analysis of water and wastes. Environmental Protection Agency, Ohio, USA.
- Harper D.M. (1992). Eutrophication of freshwaters (p. 327). London: Chapman and Hall. 327 p.
- Hilty J., Merenlender A. (2000). Faunal indicator taxa selection for monitoring ecosystem health. *Biological Conservation*, 92: 185-197.
- Javanmardi S., Rezaei Tavabe K., Moradi S., Ghafari Farsani H. (2018). Effects of various sodium adsorption ratio (SAR) at brood-stock tank water on reproductive performance of the female freshwater prawn (*Macrobrachium rosenbergii*). *Journal of Fisheries (Iranian Journal of Natural Resources)*, 71: 52-61.
- Javanmardi S., Rezaei Tavabe K., Rosentrater K.A., Solgi M., Bahadori R. (2020). Effects of different levels of vitamin B6 in tank water on the Nile tilapia (*Oreochromis niloticus*): growth performance, blood biochemical parameters, intestine and liver histology, and intestinal enzyme activity. *Fish Physiology and Biochemistry*, 46: 1909-1920.
- Markert B., Wappelhorst O., Weckert V., Herpin U., Siewers U., Friese K. (1999). The use of bioindicators for monitoring the heavy-metal status of the environment. *Journal of Radioanalytical Nuclear Chemistry*, 240: 425-429.
- McIntyre A.D., Eleftheriou A. (2005). Methods for the study of marine benthos. Blackwell Science, New Jersey, USA. 502 p.
- Mehrdadi N., Ghobadi M., Nasrabadi T., Hoveidi H. (2006). Evaluation of the quality and self-purification potential of Tajan River using QUAL2E Model. *Iranian Journal of Environmental Health Science and Engineering*, 3: 199-204.
- Nezhadheydari H., Rezaei Tavabe K., Mirvaghefi A., Heydari A., Frinsko M. (2019). Effects of different concentrations of Fe<sub>3</sub>O<sub>4</sub>@ZnO and Fe<sub>3</sub>O<sub>4</sub>@CNT magnetic nanoparticles separately and in combination on aquaculture wastewater treatment. *Environmental Technology and Innovation*, 15: 100414.
- Rafiee G., Rezaei Tavabe K., Frinsko M., Daniels H., Shoeiry M.M. (2014). Investigation on influences of different brackish water sources on larval quality and developmental indices of freshwater prawn (*Macrobrachium rosenbergii*). *Journal of Fisheries*, 67: 223-236.
- Rafiee G., Tavabe K.R., Frinsko M., Daniels H. (2015). Effects of various sodium adsorption ratio (SAR) mediums on larval performance of the freshwater prawn *Macrobrachium rosenbergii* (de Man). *Aquaculture Research*, 46: 725-735.
- Raymont J.E. (2014). Plankton and productivity in the oceans: Volume 1: Phytoplankton. Elsevier. 504 p.
- Rezaei Tavabe K., Rafiee G., Frinsko M., Daniels H. (2013). Effects of different calcium and magnesium concentrations separately and in combination on *Macrobrachium rosenbergii* (de Man) larviculture. *Aquaculture*, 412-413: 160-166.
- Rezaei Tavabe K., Malekian A., Afzali A., Taya A. (2017). Biological index and pollution assessment of Damghanroud river in the Semnan province. *Desert*, 22L 69-75.
- Rezaei Tavabe K., Pouryounes Abkenar B., Rafiee G., Frinsko M. (2019). Effects of chronic lead and cadmium exposure on the oriental river prawn (*Macrobrachium nipponense*) in laboratory conditions. *Comparative Biochemistry and Physiology Part C: Toxicology and Pharmacology*. 221: 21-28.
- Rezaei Tavabe K., Rafiee G., Elhaghi K., Mirvaghefi A., Javanshir A. (2018). Investigation of different treated urban wastewater concentrations effects on blood factors, cortisol hormone, liver and gill tissues of Common carp (*Cyprinus carpio*). *Hormozgan - Journal of Ecology*, 8: 1-13.
- Rezaei Tavabe K., Yavar M., Kabir S., Akbary P., Aminikhoie Z. (2020). Toxicity effects of multi-walled carbon nanotubes (MWCNTs) nanomaterial on the common carp (*Cyprinus carpio* L. 1758) in laboratory conditions. *Comparative Biochemistry and Physiology Part C: Toxicology and Pharmacology*, 237: 108832.

- Rezaei Tavabe K., Zare Chahouki M.A., Yazdanpanah A., Vazirzadeh A. (2010). Limnological and pollution study of Shahdadroud River, Kerman province. *Desert*, 14: 21-26.
- Rezaei Tavabe K., Kuchaksaraei B.S., Javanmardi S. (2020). Effects of ZnO nanoparticles on the Giant freshwater prawn (*Macrobrachium rosenbergii*, de Man, 1879): Reproductive performance, larvae development, CHH concentrations and anti-oxidative enzymes activity. *Animal Reproduction Science*, 221: 106603.
- Singh, K.P., Malik A., Mohan D., Sinha S. (2004). Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India) a case study. *Water Research*, 38: 3980-3992.
- Vali S., Mohammadi G., Tavabe K.R., Moghadas F., Naserabad S.S. (2020). The effects of silver nanoparticles (Ag-NPs) sublethal concentrations on common carp (*Cyprinus carpio*): Bioaccumulation, hematology, serum biochemistry and immunology, antioxidant enzymes, and skin mucosal responses. *Ecotoxicology and Environmental Safety*, 194: 110353.